AFE 76s2 Report
Derivation of Radar Altimeter Interference Tolerance Masks

Volume I: Introduction, Test Procedures, and Fundamental Test Results

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3.3.2 1000 Feet AGL

3.3.2.1 Summary

Table 3-29: UC2 1000' AGL Test Conditions

Source	Rationale	Signal Type	Characteristics	Setting
VSG	5G Fundamental OOBI	OFDM	100 MHz TM1.1 centered at 3750 MHz, 3850 MHz, 3930 MHz	Power Sweep
VCOs 1-2	Own-ship multiplex installation	FMCW	CF: 4300 MHz BW/Sweep Rate per AUT	ON*
VCOs 3-16	WCLS – other aircraft	FMCW		OFF

* – For altimeters capable of multiplex operation. Altimeters I and V had VCO's 1-2 turned off.

Table 3-30: UC2 1000' AGL OOB Fundamental Emissions Break Points

	1000 ft, Own-Ship VCOs											
	3750 MHz				3850 MHz				3930 MHz			
Altimeter	ME	1%	99%	NCD	ME	1%	99%	NCD	ME	1%	99%	NCD
A	NB	NB	NB	NB	NB	NB	NB	NB	-7 dBm*	-6 dBm	-6 dBm	-5 dBm
I	-39 dBm	-32 dBm	-52 dBm	-31 dBm*	-32 dBm	-28 dBm*	-32 dBm	-27 dBm	-25 dBm*	NB	-35 dBm	NB
S	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
V	-60 dBm	NB	-60 dBm	-60 dBm	-46 dBm	NB	-46 dBm	-46 dBm	-50 dBm	NB	-50 dBm	-50 dBm
ITM	-66 dBm				-52 dBm				-56 dBm			
PSD	-86 dBm/MHz				-72 dBm/MHz				-76 dBm/MHz			

* – Indicates engineering judgement was applied to determine break point

3.3.2.2 Altimeter A

Table 3-31: UC2 RA-A 1000' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-147	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-148	No break observed.
3850 MHz	Time History Figure 3-149	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-150	No break observed.
3930 MHz	Time History Figure 3-151 Figure 3-152	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-153 Figure 3-154	Mean error first exceeds the ±0.5% criterion threshold at -5 dBm. 1st percentile measured height is less than the -2% criterion threshold near -6 dBm. 99th percentile measured height is greater than the +2% criterion threshold near -6 dBm. An NCD occurs at -5 dBm. Subject matter experts examined the expanded time history plot shown in Figure 3-152 and determined that the RA's performance is clearly affected by 5G RF interference at -7 dBm and thus applied engineering judgement to set the break point at -7 dBm.

Center Frequency = 3750 MHz

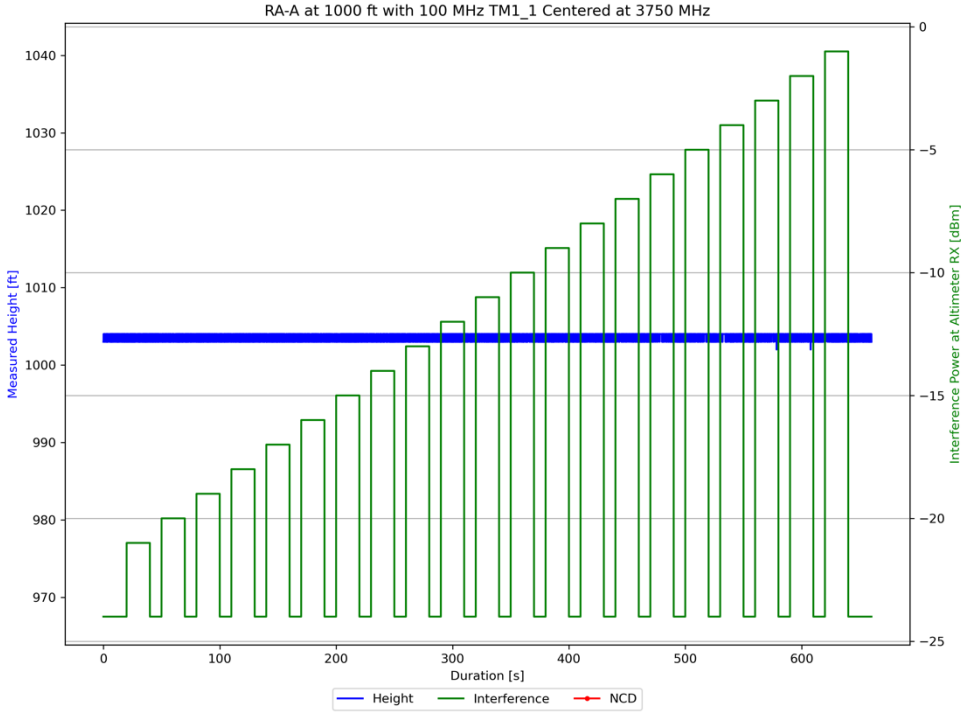

Figure 3-147: UC2 RA-A 1000' AGL Time History with TM1.1 at 3750 MHz

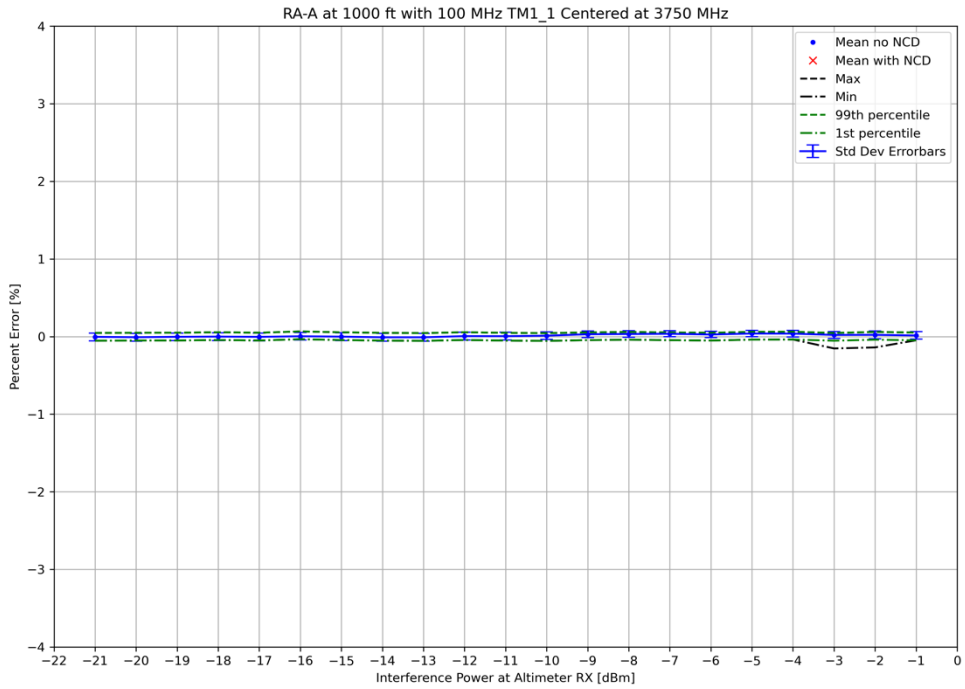

Figure 3-148: UC2 RA-A 1000' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

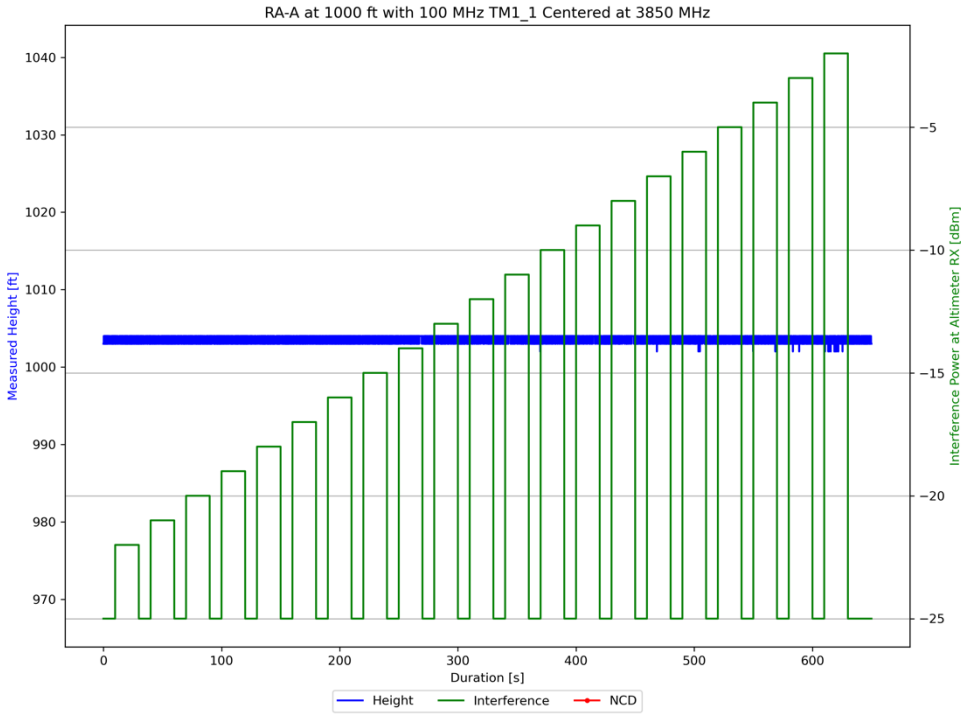

Figure 3-149: UC2 RA-A 1000' AGL Time History with TM1.1 at 3850 MHz

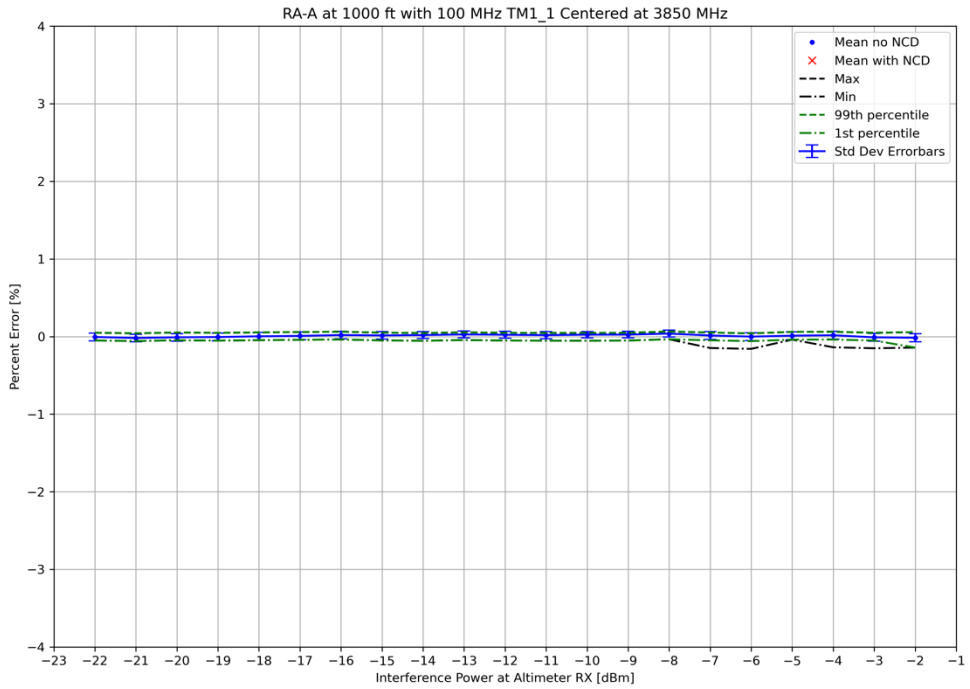

Figure 3-150: UC2 RA-A 1000' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

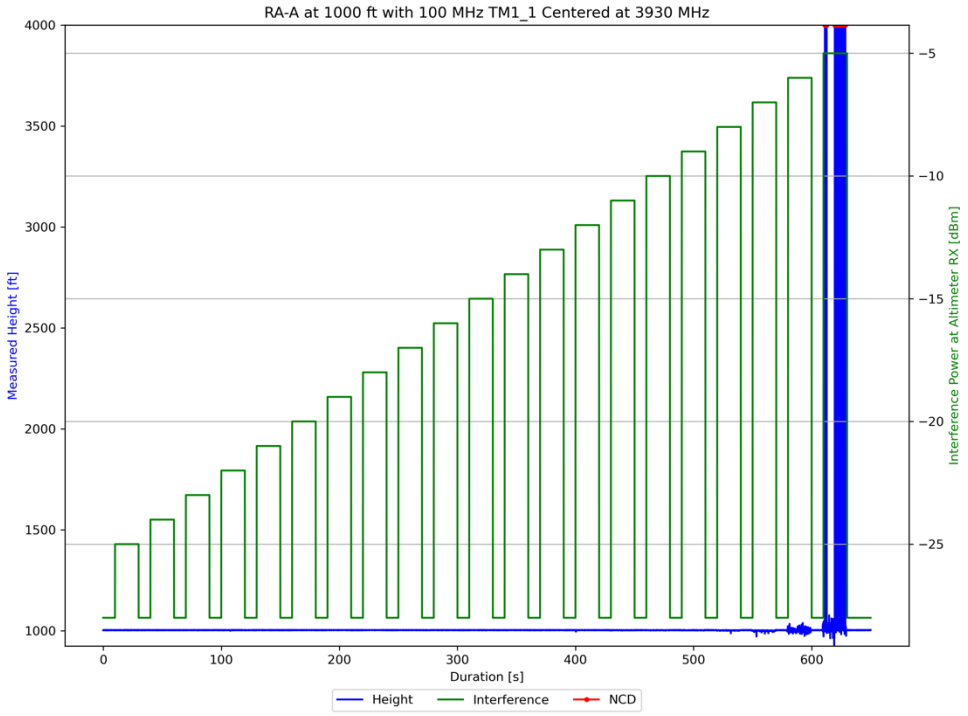

Figure 3-151: UC2 RA-A 1000' AGL Time History with TM1.1 at 3930 MHz

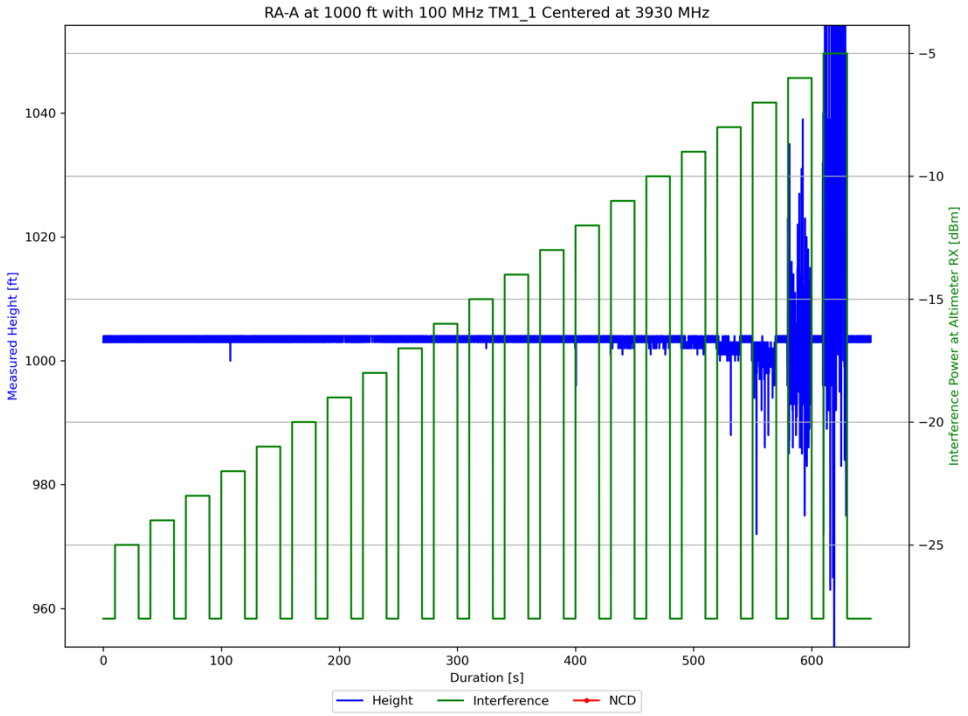

Figure 3-152: UC2 RA-A 1000' AGL Time History with TM1.1 at 3930 MHz – Zoomed In

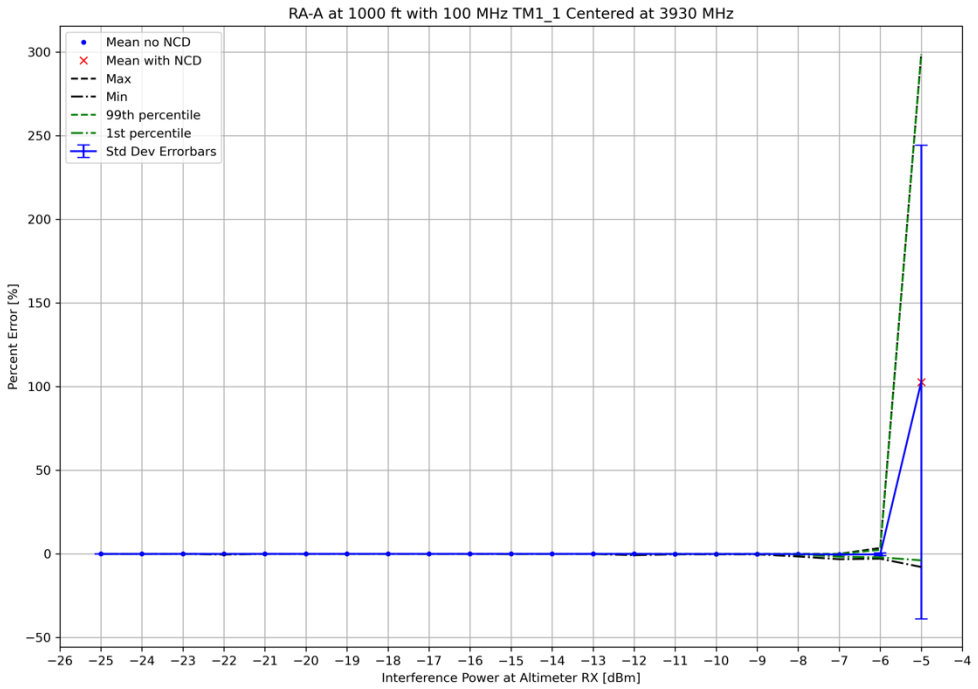

Figure 3-153: UC2 RA-A 1000' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

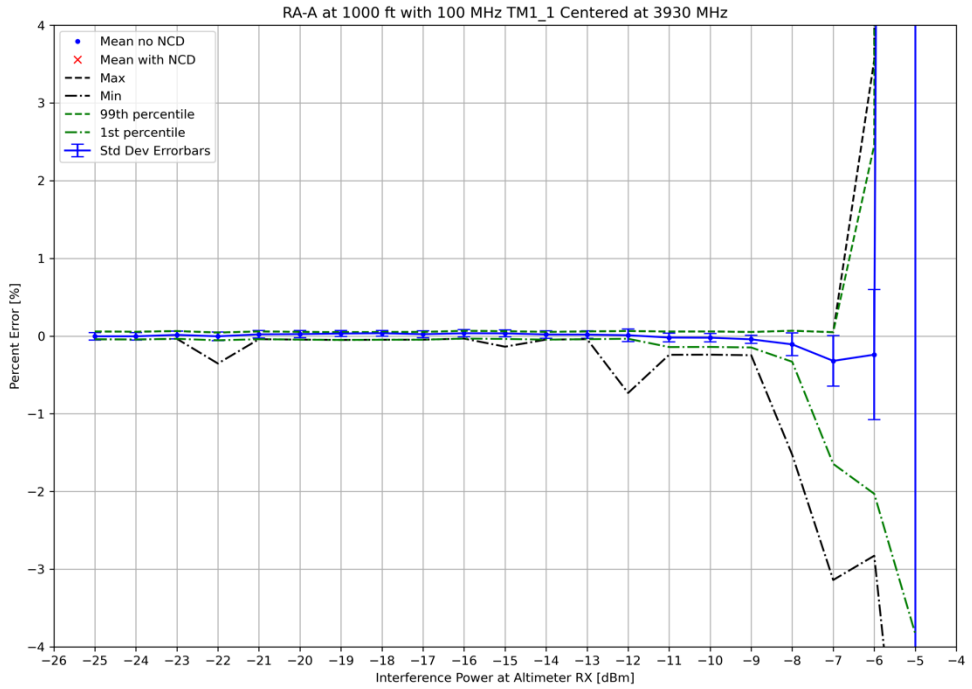

Figure 3-154: UC2 RA-A 1000' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In

3.3.2.3 Altimeter I

For Altimeter I at 1000 feet AGL, valid measured heights appear to be rounded to the nearest 50 feet. Subject matter experts agreed it was necessary to apply engineering judgement to take this height quantization into account when determining the break points.

Table 3-32: UC2 RA-I 1000' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-155 Figure 3-156	Show the magnitude of change in measured height over time for increasing interference power levels for both full vertical and magnified vertical scales.
	Statistics Figure 3-157 Figure 3-158	99th percentile measured height is greater than the +2% criterion threshold near -52 dBm. Mean error first exceeds the ±0.5% criterion threshold near -39 dBm. 1st percentile measured height is less than the -2% criterion threshold near -32 dBm. An NCD occurs near -31 dBm. While all criteria except NCD indicate a lower threshold value, subject matter experts reviewed the time history plot and expanded statistics plot and observed that given the measured height quantization and relatively stable measured height up to -31 dBm, engineering judgment suggests that the break point is set by the NCD criterion at -31 dBm.
3850 MHz	Time History Figure 3-159	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-160 Figure 3-161	Mean error first exceeds the ±0.5% criterion threshold at -32 dBm. 99th percentile measured height is greater than the +2% criterion threshold at -32 dBm. 1st percentile measured height is less than the -2% criterion threshold at -28 dBm. An NCD occurs at -27 dBm. While the mean error and 99th percentile criteria indicate a lower threshold value, subject matter experts reviewed the time history plot and expanded statistics plot and observed that given the measured height quantization and relatively stable measured height up to -28 dBm, engineering judgment suggests that the break point is set by the 1st percentile criterion at -28 dBm.

Center Frequency	Plot	Comments
3930 MHz	Time History Figure 3-162	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-163 Figure 3-164	Mean error first exceeds the ±0.5% criterion threshold at -31 dBm. 99th percentile measured height is greater than the +2% criterion threshold at -35 dBm. While the mean error and 99th percentile criteria indicate a lower threshold value, subject matter experts reviewed the time history plot and expanded statistics plot and observed that given the measured height quantization and relatively stable measured height up to -25 dBm, engineering judgment assigns the mean error break point at -25 dBm.

Center Frequency = 3750 MHz

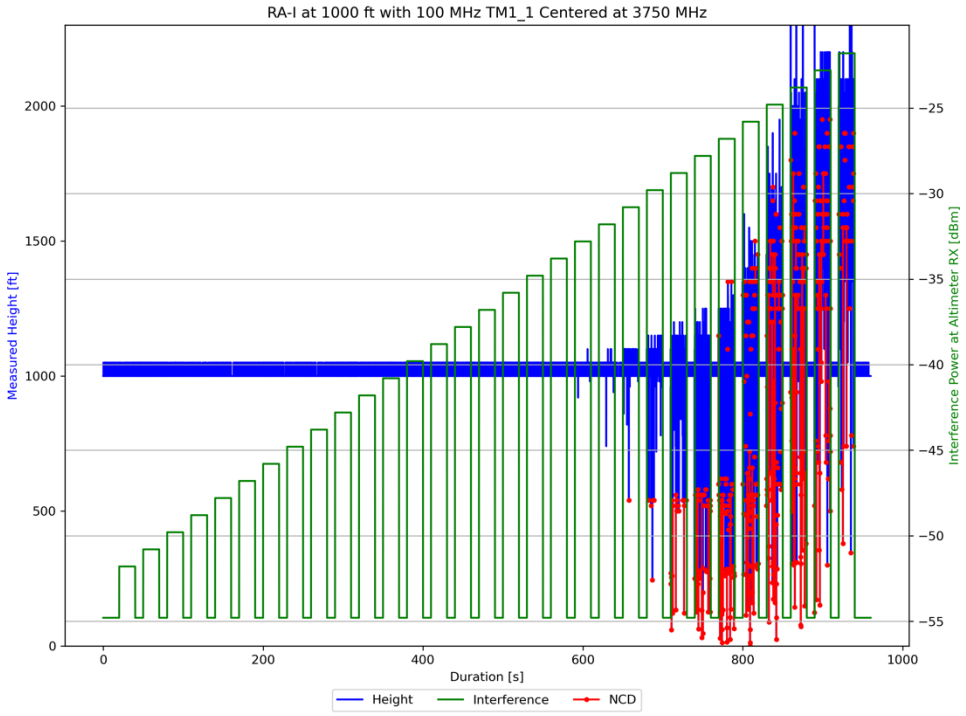

Figure 3-155: UC2 RA-I 1000' AGL Time History with TM1.1 at 3750 MHz

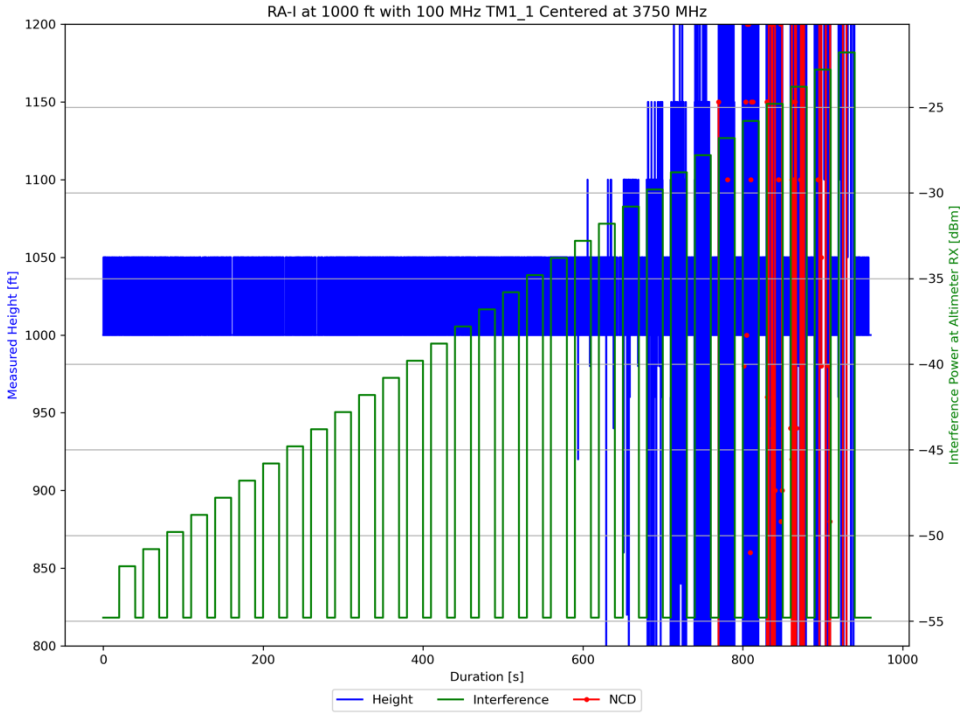

Figure 3-156: UC2 RA-I 1000' AGL Time History with TM1.1 at 3750 MHz – Zoomed In

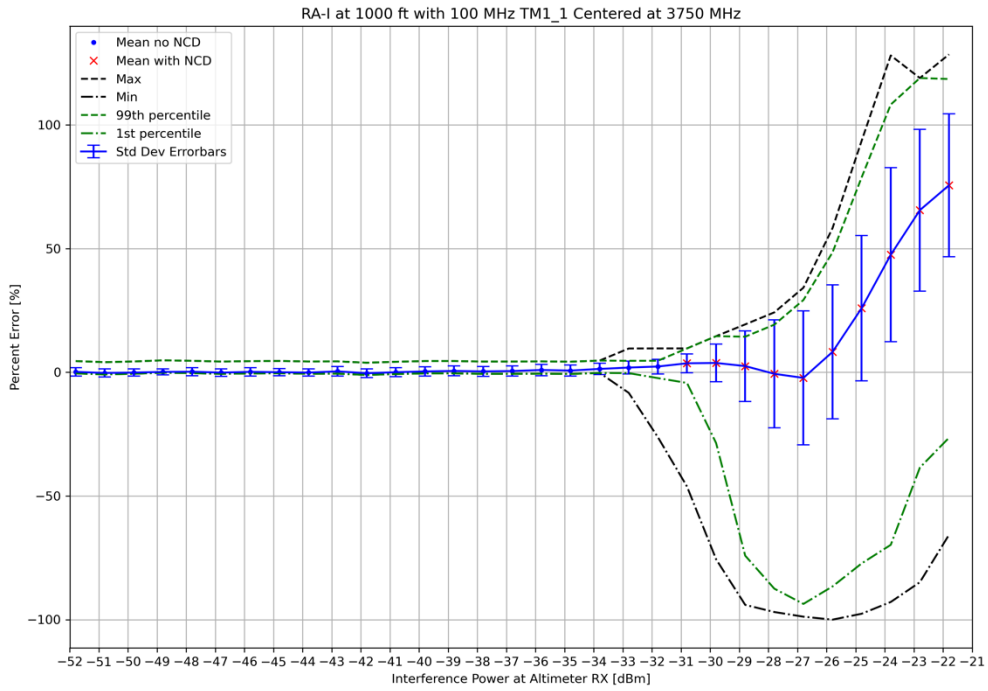

Figure 3-157: UC2 RA-I 1000' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

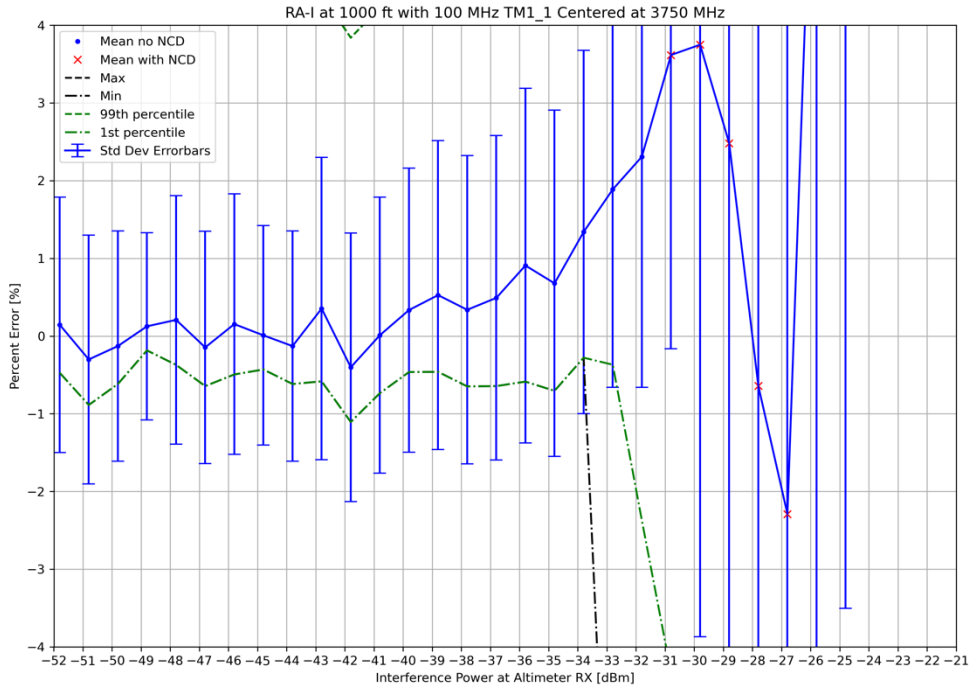

Figure 3-158: UC2 RA-I 1000' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

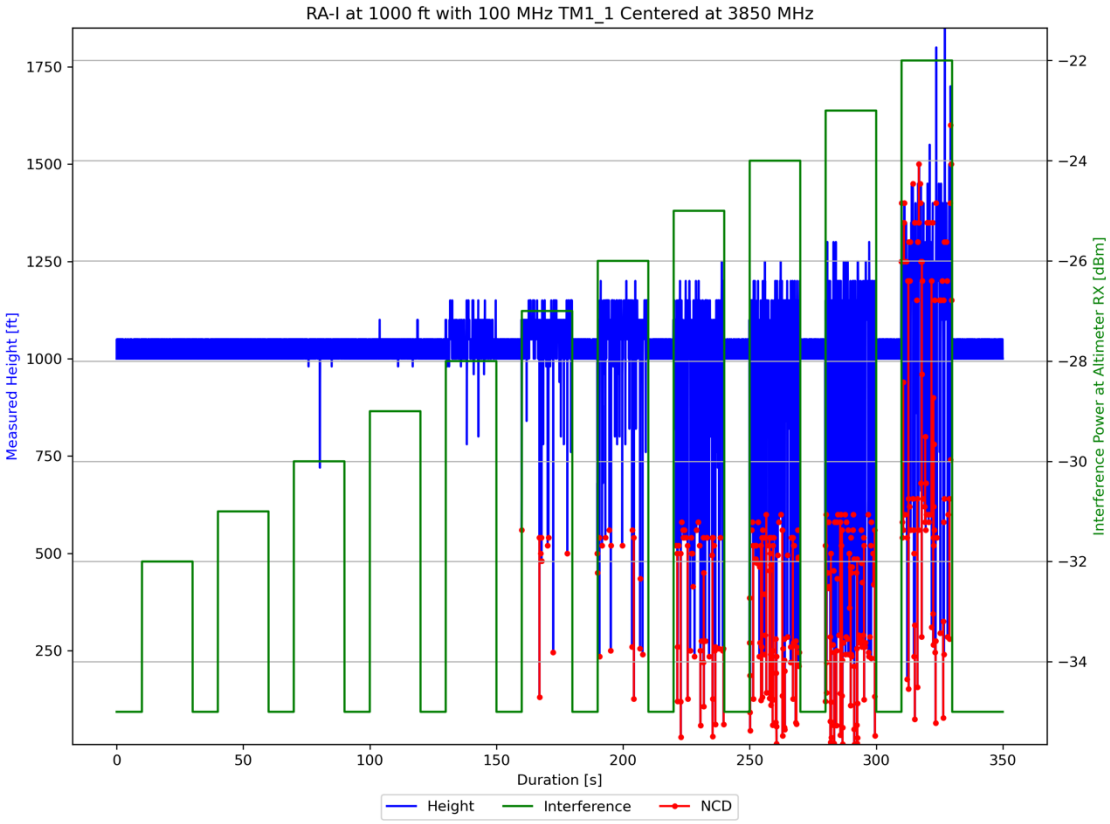

Figure 3-159: UC2 RA-I 1000' AGL Time History with TM1.1 at 3850 MHz

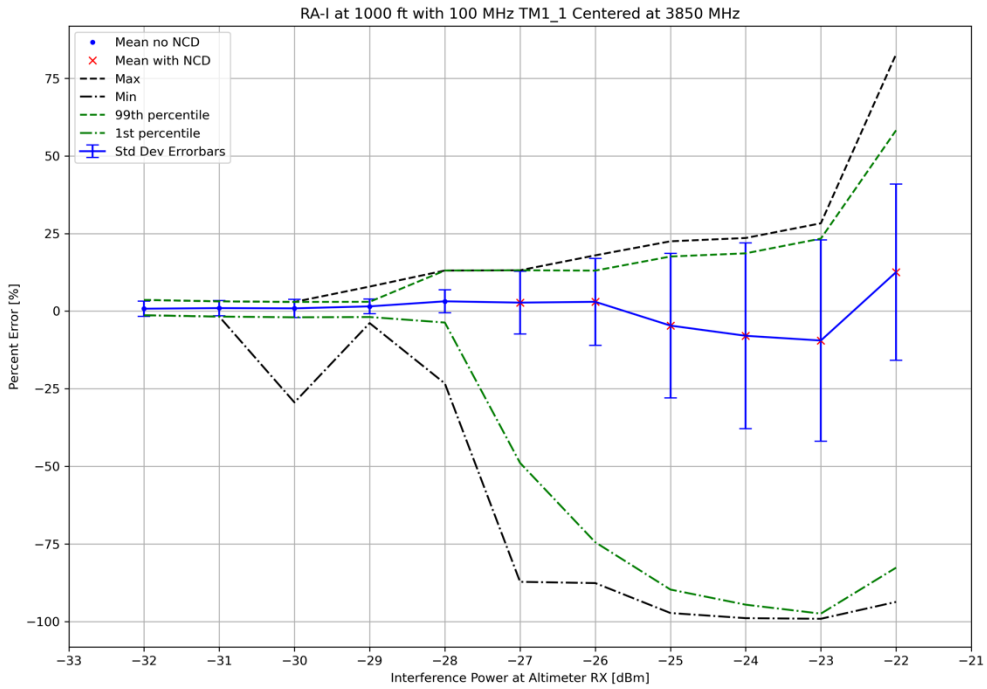

Figure 3-160: UC2 RA-I 1000' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

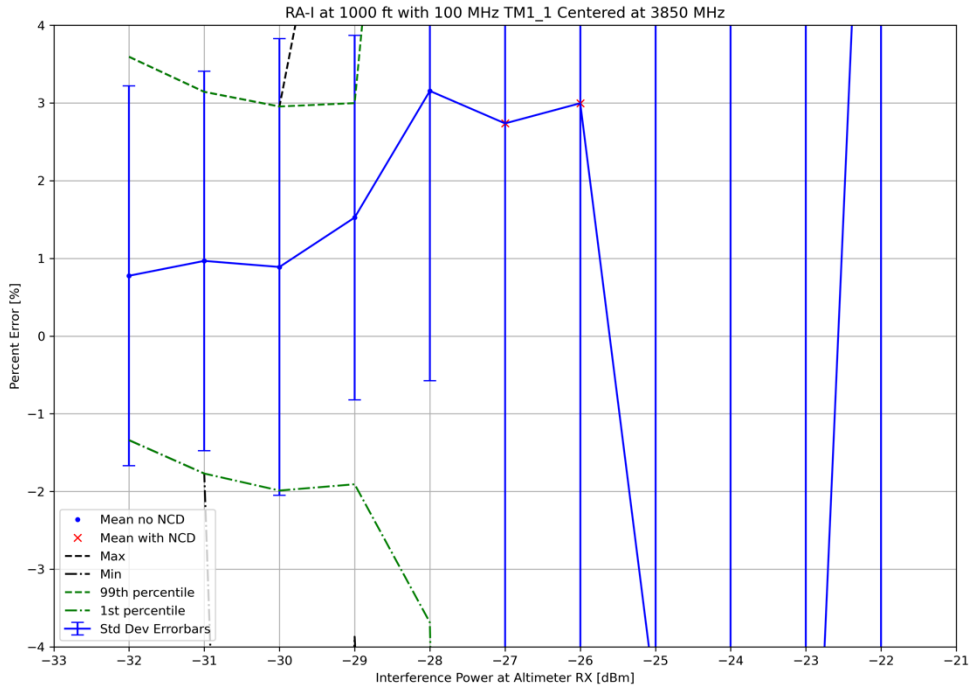

Figure 3-161: UC2 RA-I 1000' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

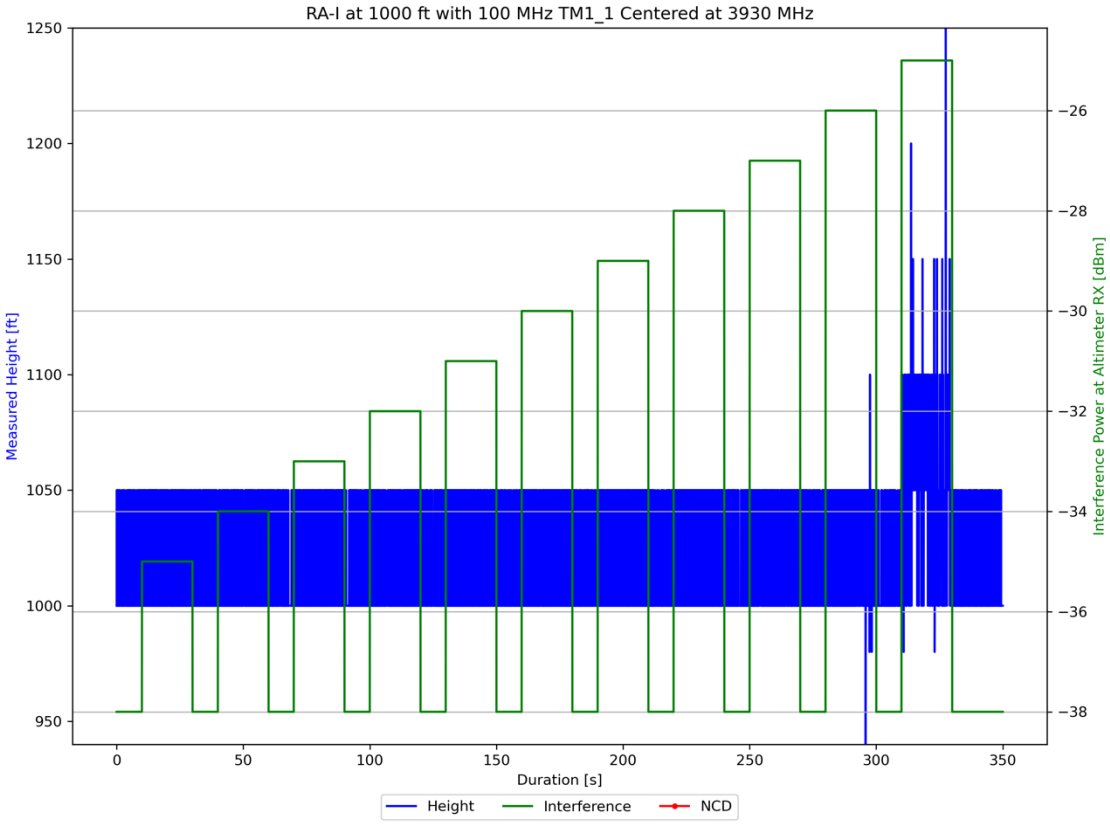

Figure 3-162: UC2 RA-I 1000' AGL Time History with TM1.1 at 3930 MHz

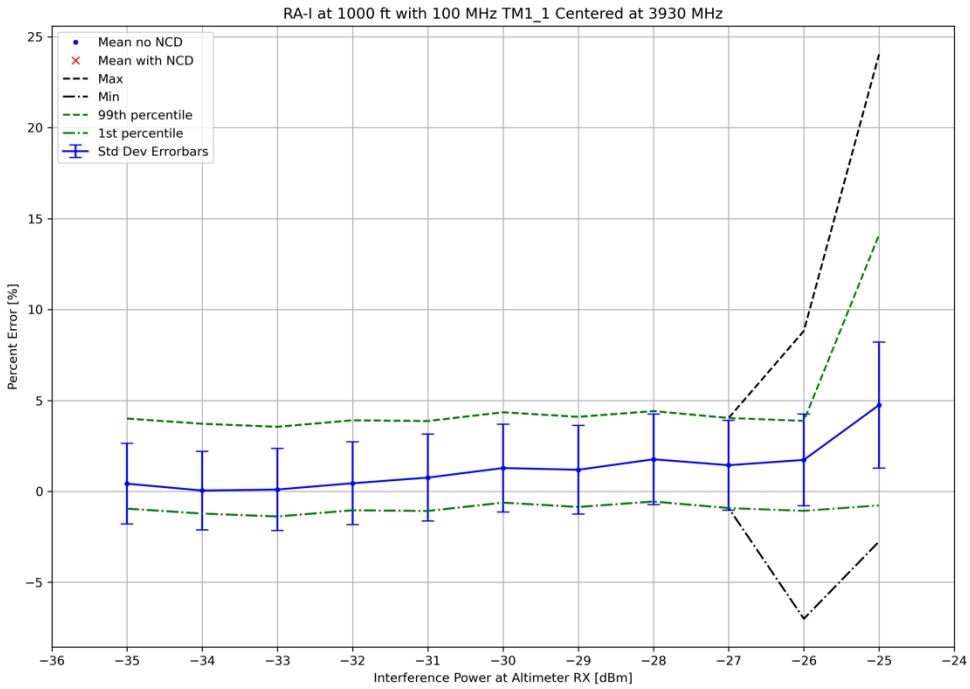

Figure 3-163: UC2 RA-I 1000' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

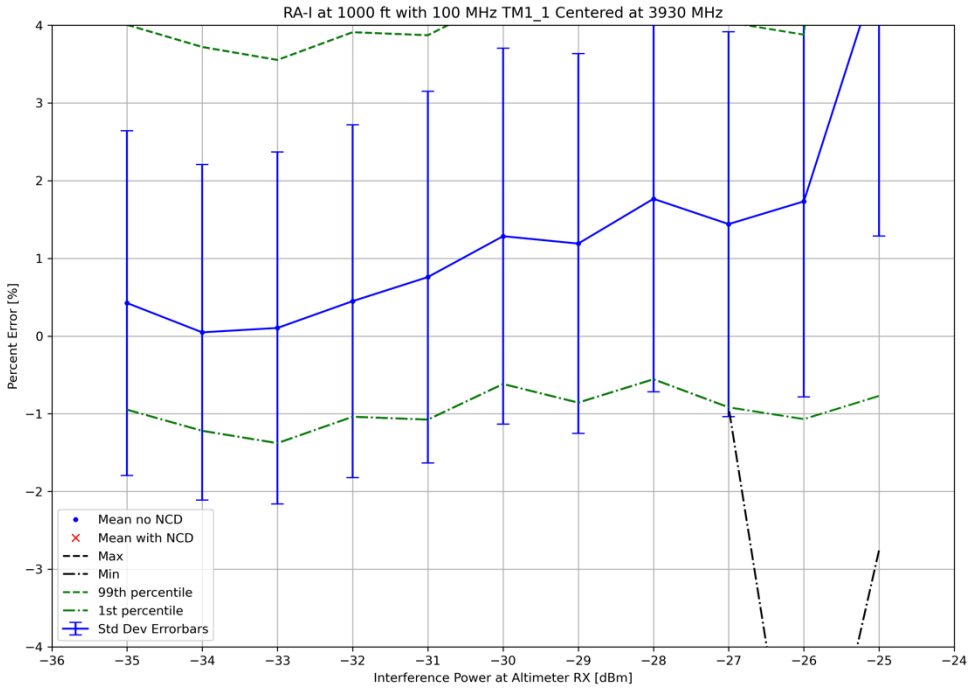

Figure 3-164: UC2 RA-I 1000' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In

3.3.2.4 Altimeter S

Table 3-33: UC2 RA-S 1000' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-165	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-166	No break observed.
3850 MHz	Time History Figure 3-167	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-168	No break observed.
3930 MHz	Time History Figure 3-169	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-170	No break observed.

Center Frequency = 3750 MHz

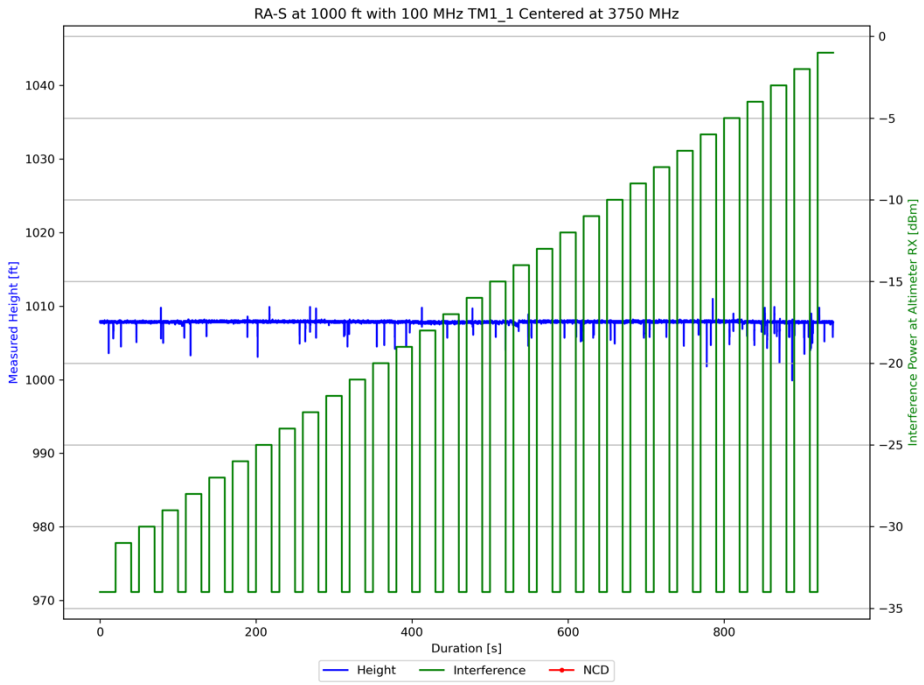

Figure 3-165: UC2 RA-S 1000' AGL Time History with TM1.1 at 3750 MHz

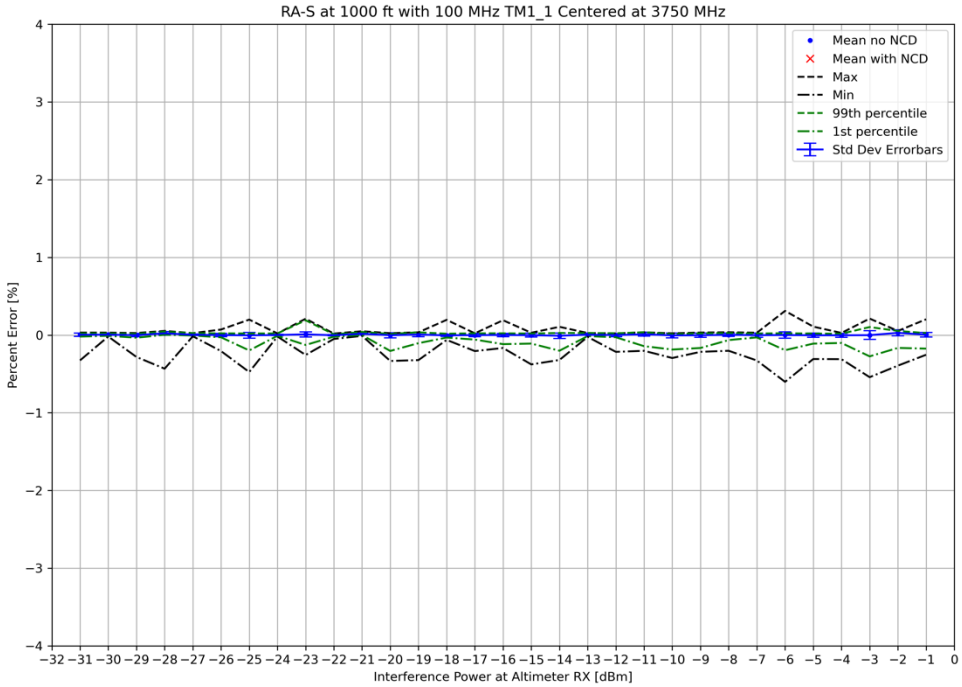

Figure 3-166: UC2 RA-S 1000' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

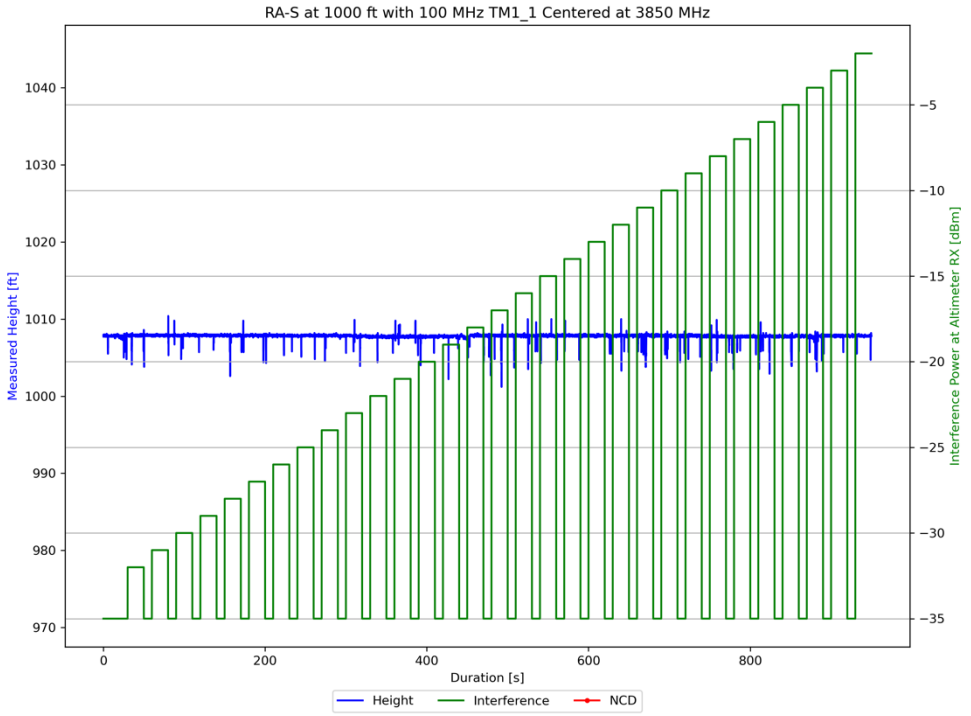

Figure 3-167: UC2 RA-S 1000' AGL Time History with TM1.1 at 3850 MHz

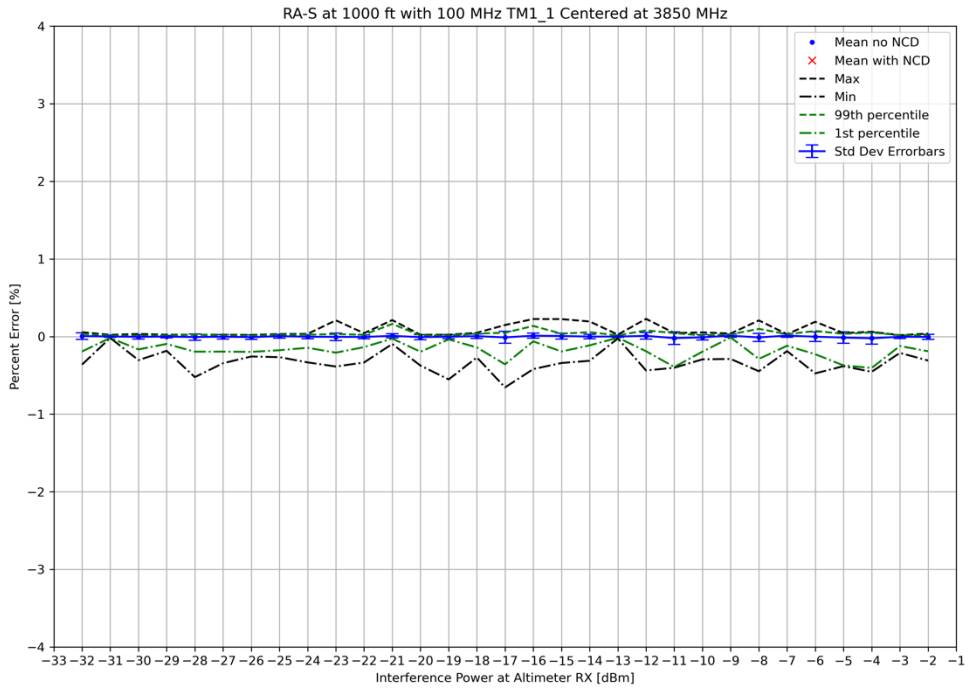

Figure 3-168: UC2 RA-S 1000' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

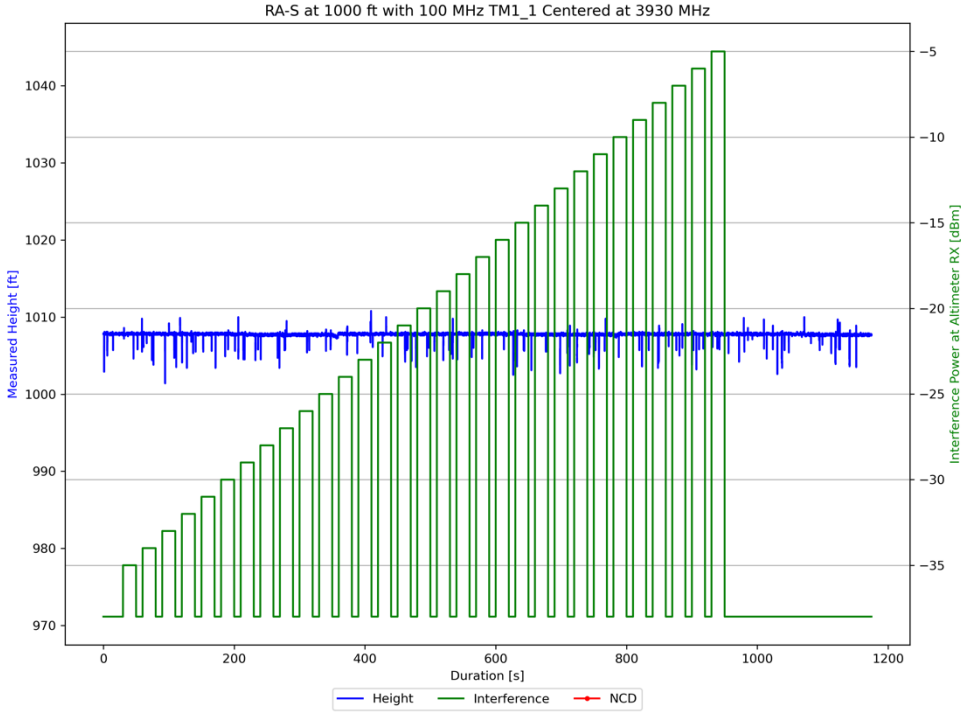

Figure 3-169: UC2 RA-S 1000' AGL Time History with TM1.1 at 3930 MHz

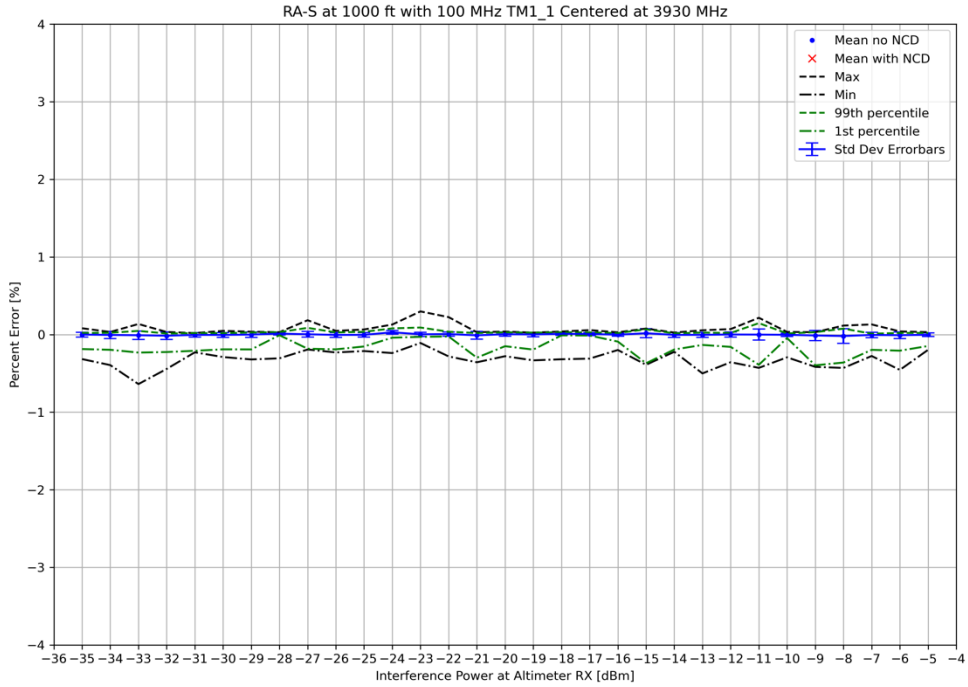

Figure 3-170: UC2 RA-S 1000' AGL Statistics with TM1.1 at 3930 MHz

3.3.2.5 Altimeter V

Table 3-34: UC2 RA-V 1000' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-171	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-172 Figure 3-173	Mean error greater than 0.5%, 99th percentile greater than 2%, and NCD criteria break points occur at -60 dBm. Note that this altimeter reports 4000 feet when an NCD occurs, thus the NCD criterion sets the break point since this affects the other statistics.
3850 MHz	Time History Figure 3-174	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-175 Figure 3-176	Mean error greater than 0.5%, 99th percentile greater than 2%, and NCD criteria break points occur at -46 dBm. Note that this altimeter reports 4000 feet when an NCD occurs, thus the NCD criterion sets the break point since this affects the other statistics.
3930 MHz	Time History Figure 3-177	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-178 Figure 3-179	Mean error greater than 0.5%, 99th percentile greater than 2%, and NCD criteria break points occur at -50 dBm. Note that this altimeter reports 4000 feet when an NCD occurs, thus the NCD criterion sets the break point since this affects the other statistics.

Center Frequency = 3750 MHz

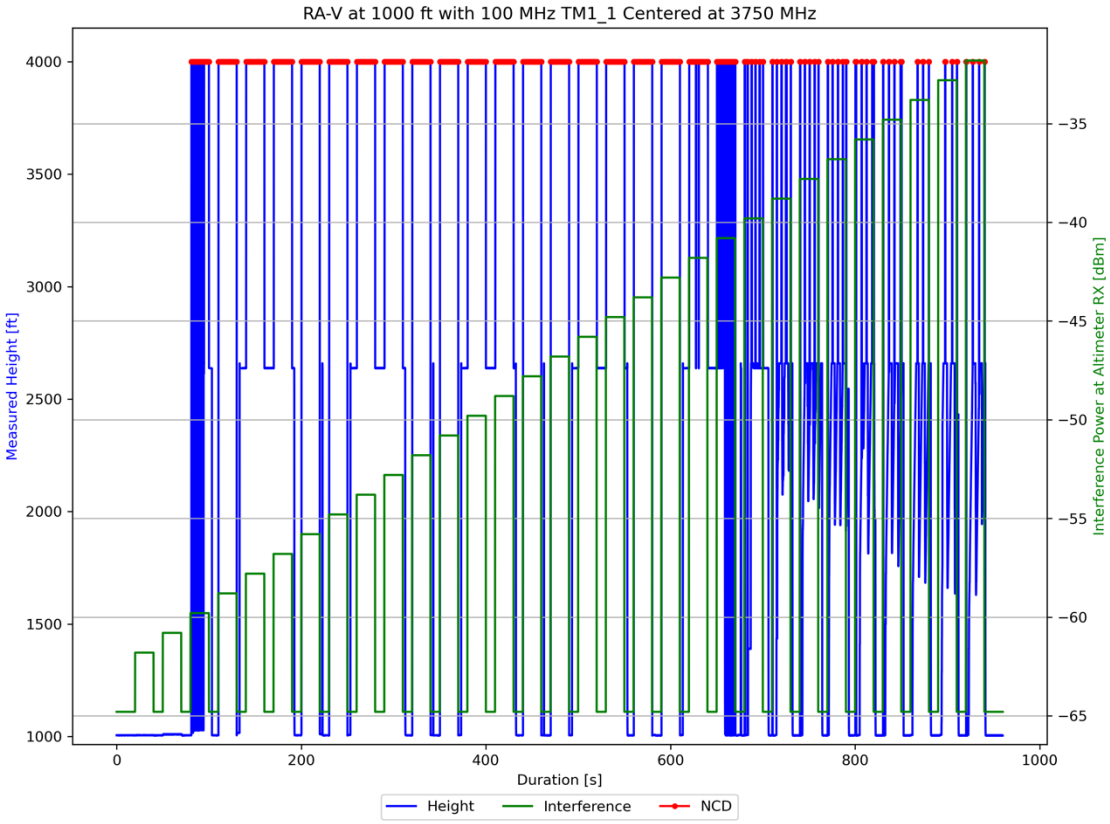

Figure 3-171: UC2 RA-V 1000' AGL Time History with TM1.1 at 3750 MHz

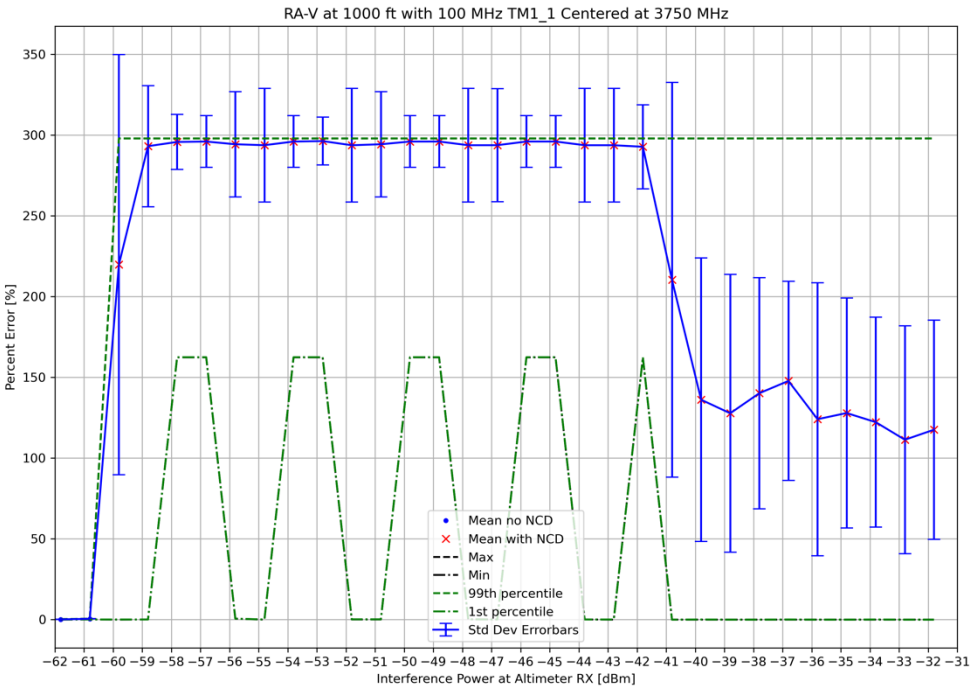

Figure 3-172: UC2 RA-V 1000' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

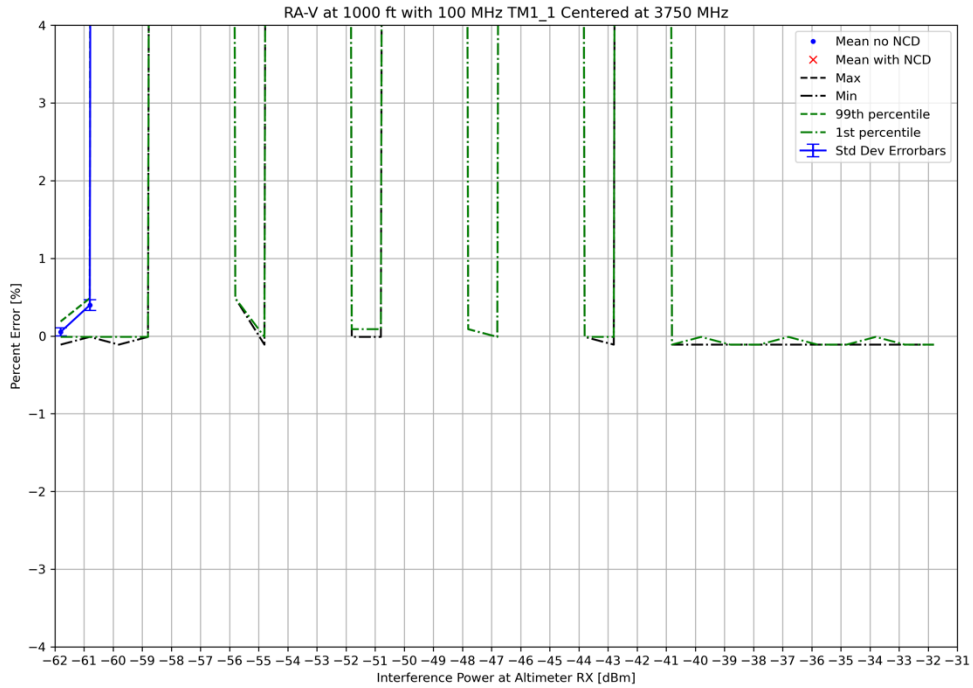

Figure 3-173: UC2 RA-V 1000' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

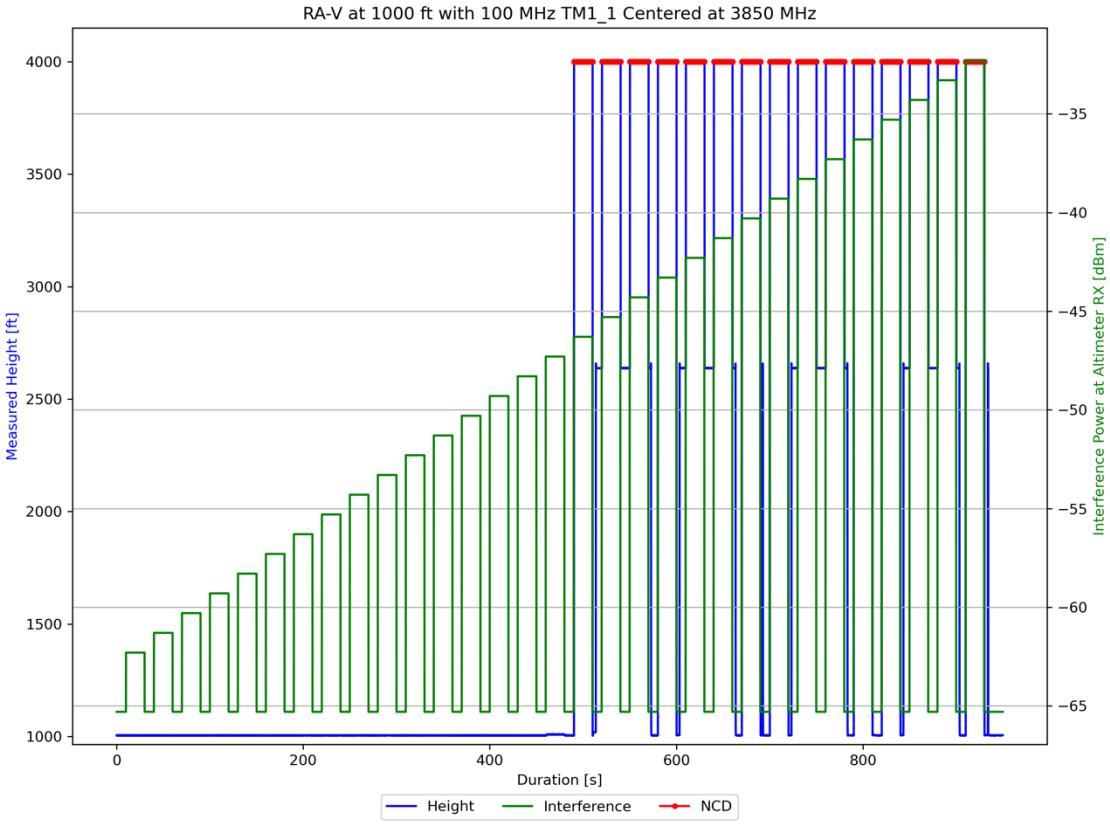

Figure 3-174: UC2 RA-V 1000' AGL Time History with TM1.1 at 3850 MHz

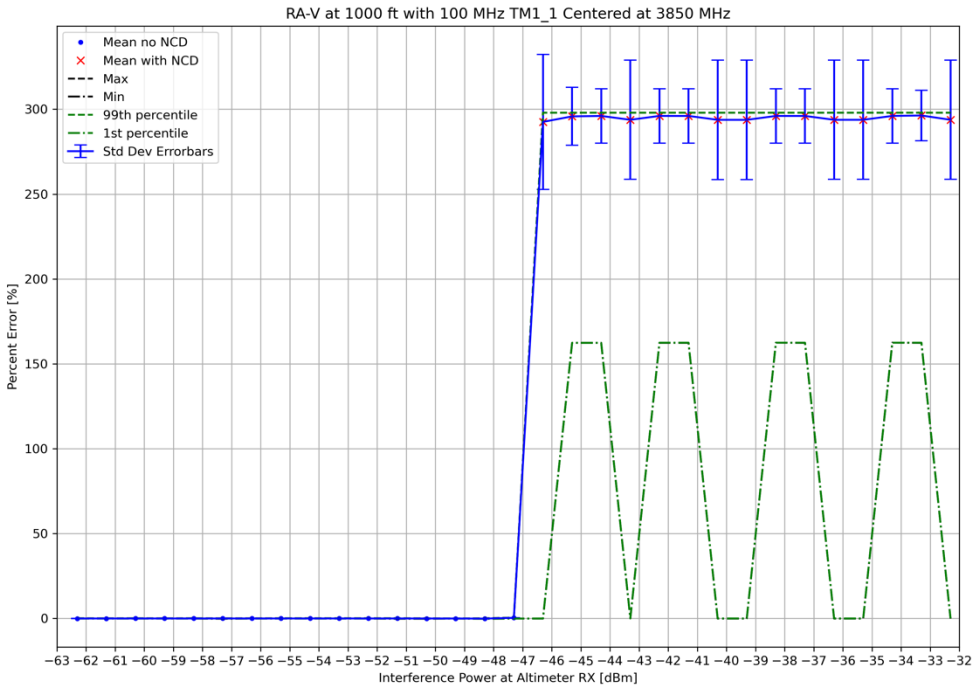

Figure 3-175: UC2 RA-V 1000' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

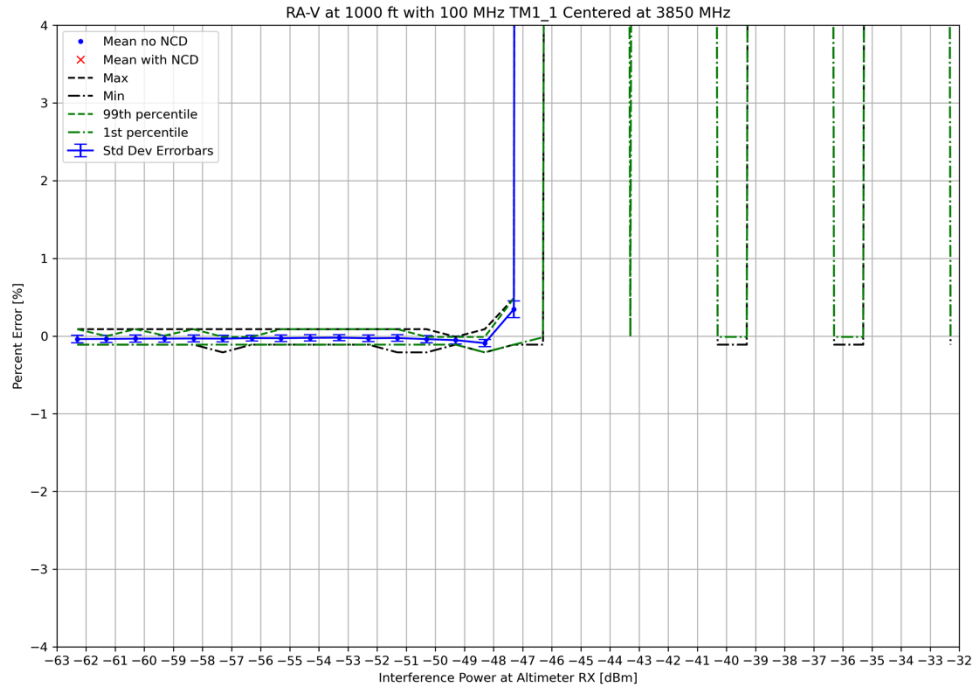

Figure 3-176: UC2 RA-V 1000' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

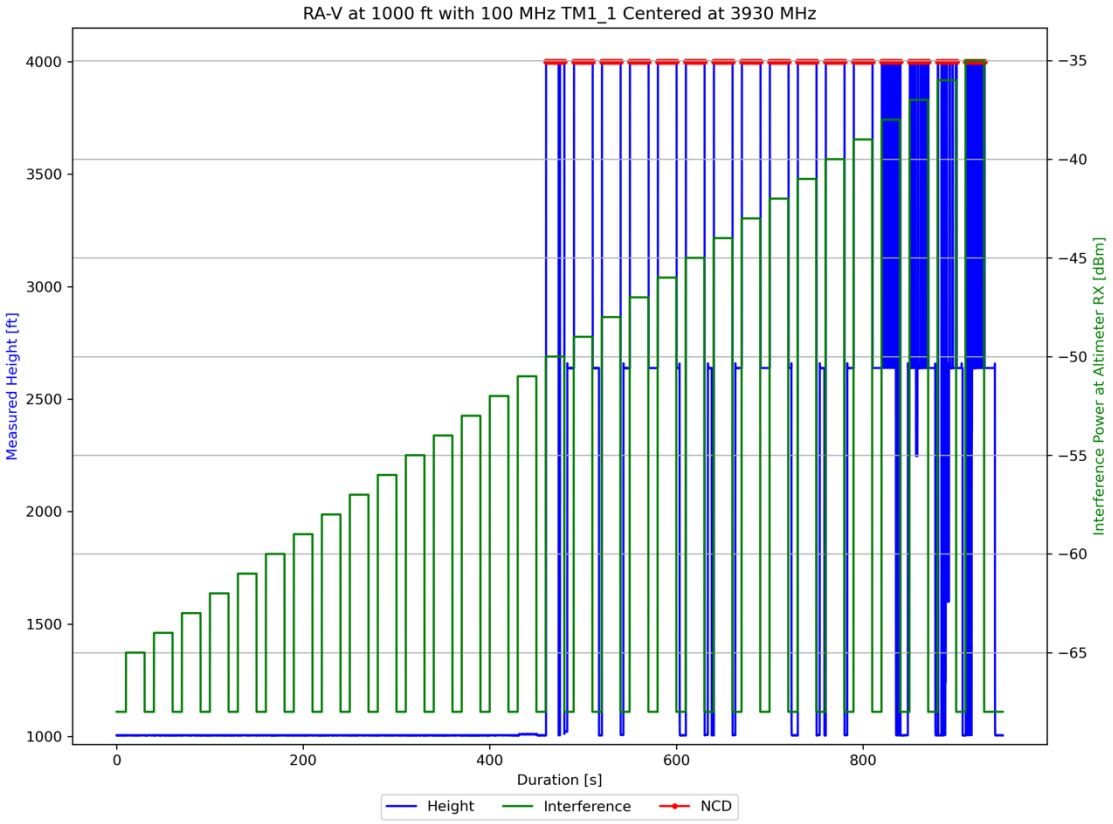

Figure 3-177: UC2 RA-V 1000' AGL Time History with TM1.1 at 3930 MHz

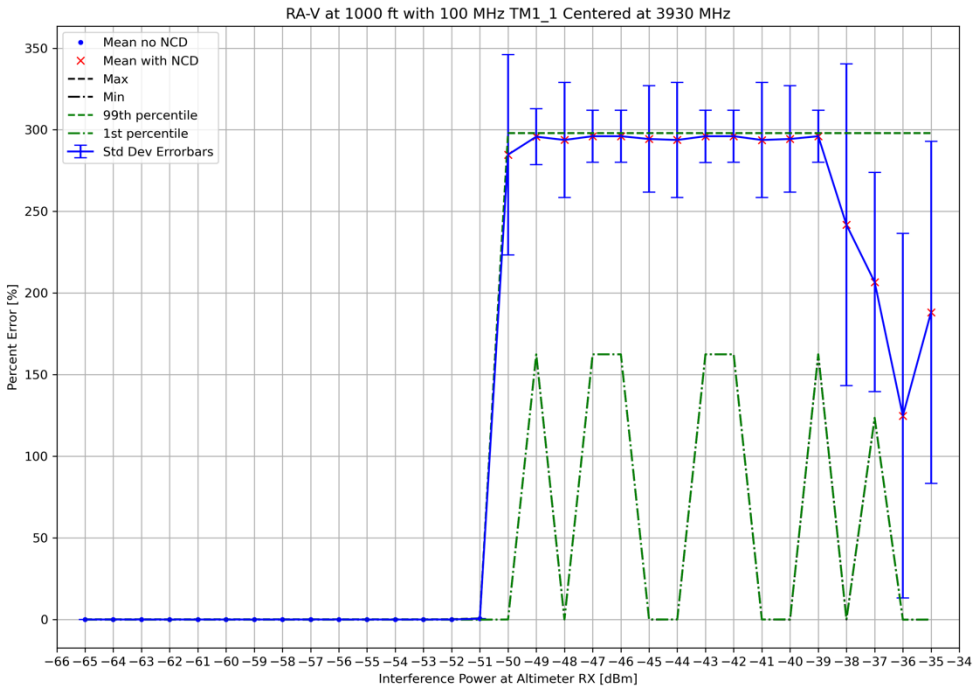

Figure 3-178: UC2 RA-V 1000' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

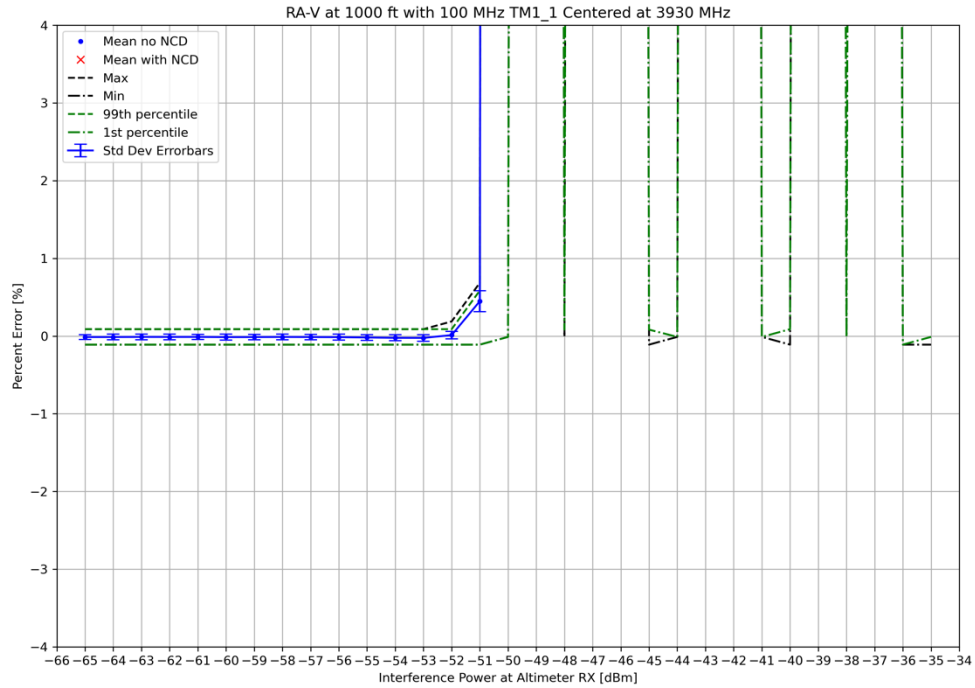

Figure 3-179: UC2 RA-V 1000' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In